

Data Systems & Solutions

A Joint Venture of SAIC and Rolls-Royce plc.

NPP Licensed Operator Training

Full-Scope Simulators Running Real-time RELAP5-R/T

Ken A. Williams, Ph.D., P.E.



DS&S RELAP5-R/T NPP Simulator Upgrades

- All upgrades must be ANSI/ANS-3.5 compliance
- TXU - Comanche Peak PWR NPP Upgrade of the RCS, S/G and all Feedwater Systems
- PSE&G - Salem PWR Upgrade of the RCS & Core
- PSE&G - Hope Creek BWR Upgrade of the RCS & Core
- APS - Palo Verde PWR NPP Upgrade of the RCS and Core
- NAESCO - Seabrook PWR RCS, S/G, Core
- Bohunice - VVER 440 Upgrade of the RCS & Core

Operator Training with RELAP5-R/T Means Enhanced Confidence & Cost Savings

- *Confidence*: High fidelity simulation of plant response under all modes... “the simulator looks like the plant”
 - Complex thermal-hydraulic and neutronic behavior are predicted by “first principle” phenomena models and conservation laws
 - Complex NPP Phenomena: Superheating with quality < 1 (e.g., CET), counter-current flows, CCFL, non-condensable gas, condensation shocks, water hammer, loop levels, RHR vortex (air ingress), SG tube “coke bottle”
 - Design-basis accidents (including LBLOCA w/ delayed ECCS)
 - EOP evaluation with safety-grade engineering code
 - DS&S RELAP5 Simulator Users Consortium will keep advancing the code for operator training

Operator Training with RELAP5-R/T Means Enhanced Confidence & Cost Savings

- *Cost Savings: Realistic simulator response under all modes allows for training in “new” regimes*
 - Realistic training for drain down to mid-loop and refill
 - CPSES has added “purge and vacuum” functionality
 - PVNGS has studied loss of cooling during mid-loop
 - Salem has improved S/G level response under SGTR (WOG interest)
 - EPRI studied degraded SG EOP procedures and briefed to NRC
 - Feedwater responds dynamically: CPSES used the simulator to design heater drain tank mods and eliminated LP heater bypass problem

DS&S Modifications to RELAP5-R/T for SIMULATOR USER CONSORTIUM

- Log-averaged (time) wall htc
Log-weighted 0.9 to last time value
- Rate-limited condensation heat transfer
Applied when $P < 10^{**6}$ Pa
- Frictional Choking
Applied if $Ma > 0.8$
- Upper limits on heat transfer coefficient
 $htc < 50,000$ w/m**2/K
- JCHOKe limits
Convergence problems in subroutine
- Subcooled boiling
Applied when $P < 10^{**6}$ Pa no subcooled boiling



RHR Vortex In Cold Leg During Withdrawal

